XV. *Contributions to Animal Chemistry.*—Paper V.

On the Oxidation of Ammonia in the Human Body, with some Remarks on Nitrification.

By Henry Bence Jones, *M.D., M.A. Cantab., F.R.S., Physician to St. George's Hospital.*

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In a paper lately communicated to the Royal Society, I showed that the effect of tartrate of ammonia on the acidity of the urine was totally different from that of tartrate of potash; and that carbonate of ammonia taken in very large quantities did not produce any alkaline reaction of the urine; on the contrary, the acidity was rather increased than diminished by large doses of carbonate of ammonia. I repeated these experiments with carbonate of ammonia, hoping to obtain more decided results; but I could not determine the fact of any great increase in the acidity of the urine, although it was again apparent that no diminution of the acid reaction resulted from taking carbonate of ammonia.

I also repeated these experiments on many patients in St. George's Hospital suffering from chronic rheumatism, but though some took on an average 50 grs. of carbonate of ammonia daily for seven or more weeks, yet no alkaline state of the urine could be produced.

In consequence of these observations, I suggested in my paper that an inquiry into the occurrence of nitric acid in the urine would probably give the solution of this unexpected effect of carbonate of ammonia.

Hitherto but few observations have been made on the occurrence of nitric acid in the urine in health or disease. Dr. Prout, in the Medico-Chirurgical Transactions, vol. ix. p. 481, mentions that he found nitric acid in the pink sediment from the urine of those labouring under febrile and inflammatory diseases, but he says nothing of the urine containing it in solution; hence, possibly, it came from the baryta used in the process of testing the sediment. Wurtzer also obtained nitric acid; Lehmann thinks, that in this case also it came from the impure baryta.

Thus, then, regarding the presence of nitric or nitrous acids in the urine our knowledge is deficient. Moreover, the difficulty of recognizing very small quantities of nitric acid is considerable, and the accurate determination of the quantity present in organic liquids is almost impossible.

Through the kindness of Mr. Faraday I was allowed the use of the laboratory at the Royal Institution, and I obtained the assistance of Dr. Price to conduct my experiments without interruption.

The delicacy of the different tests for nitric acid was first ascertained, and then a

series of experiments was made to determine what was the smallest amount of nitrate of potash that could be detected in the urine when nitre was dissolved in the water after it had passed out of the body.

The indigo test for nitric acid being more delicate than the protosulphate of iron test, it was chiefly employed. But far more delicate than either test was a mixture of starch with one drop or two of a solution of hydriodate of potash, specific gravity 1052, and very dilute hydrochloric acid, specific gravity 1005. This test Dr. PRICE suggested to me, and the precautions necessary in its use and its advantages he will more fully describe elsewhere. Depending on the production of a deep colour, and not on the removal of colour, it gave evidence when the indigo test afforded none; and if the quantity of iodide of potassium was very small, and if the hydrochloric acid was very dilute, comparative experiments showed that reliance could be placed upon this test.

In the examination of the urine the method was this. From four to eight ounces were taken, and if a larger quantity was passed, it was evaporated to about this quantity in a water-bath, and then mixed with half an ounce of strong and pure sulphuric acid, perfectly free from every trace of nitric acid. Distillation was carried on in a retort until at least two thirds of the fluid had passed into the receiver, when the distillate was neutralized with pure carbonate of potash and evaporated to a very small bulk. From a drop to half the residue was added to the mixture of starch, hydriodate of potash and dilute hydrochloric acid. Another portion was placed in a bason; a very small quantity of indigo was added with an excess of sulphuric acid, and heat was applied for some minutes. The greenish colour of the indigo with the residue of the distillate arose from a small quantity of yellow colouring matter which came over in the distillation and grew darker by evaporation. If too much indigo was used, slight traces of nitric acid could not be detected. Occasionally the protosulphate of iron was also used as a test.

Beginning at first with 10 grs. of nitrate of potash added to 10 ounces of urine, it was found at last that as little as 1 gr. of nitrate to 10 ounces of urine could be detected by this process when the starch test was used, with the greatest certainty and clearness. This quantity could not be detected as surely by the indigo and sulphuric acid test.

Healthy urine was first examined to see if it contained nitric acid.

(1.) One hundred and twenty ounces, the produce of five persons, were evaporated to a small bulk; on distillation with sulphuric acid no nitric acid could be found.

(2.) Thirty ounces, the produce of two other persons, were examined, and no nitric acid was found.

(3.) Twenty ounces of urine, passed by a healthy man, were concentrated and distilled, but no nitric acid was found.

The same person was then made the subject of the following experiments:—

Experiments with Carbonate of Ammonia.

Breakfast was usually taken at 8 o'clock and dinner at 6 o'clock. Both meals consisted of mixed diet; cocoa was taken at breakfast, and water only at dinner.

(4.) At $11^h\ 40^m$ A.M. a single dose of 40 grs. of carbonate of ammonia was taken dissolved in 8 ounces of distilled water.

At 3 P.M. 8 ounces of urine were passed, which gave very decided evidence of nitric acid by the indigo test and by the starch test.

At 6 P.M. 15 ounces of water: no result was obtained in consequence of an accident.

At 11 P.M. 9 ounces. By the indigo test no nitric acid was found. By the starch test a slight trace of nitric acid was detectable.

At $7^h\ 25^m$ A.M. 14 ounces. Gave no evidence of nitric acid by either test.

Up to $7^h\ 25^m$ A.M. the following day 41 ounces of urine were passed. In this large quantity the indigo test gave no nitric acid; but the starch test still showed slight evidence of the presence of the acid.

Thus then after 40 grs. of carbonate of ammonia, nitric acid could be detected in the urine made three hours after the ammonia was taken. After twelve hours a trace was perceptible, and after twenty hours it had not altogether disappeared.

(5.) This experiment was again repeated on the same person.

At $7^h\ 20^m$ A.M. 16 ounces of urine were passed; on examination no trace of nitric acid could be detected by the indigo or starch tests. 40 grs. of carbonate of ammonia were taken, dissolved in distilled water; very active exercise followed for nearly an hour after the volatile alkali was taken.

At $8^h\ 40^m$ A.M. 4 ounces of urine were passed, and breakfast was then taken; nitric acid was found to be present in considerable quantity, both by the indigo and starch tests.

At $12^h\ 30^m$ A.M. 7 ounces of urine gave no proof of nitric acid by the indigo test, but distinct evidence by the starch test.

At $3^h\ 30^m$ P.M. 5 ounces. Gave no proof by indigo; less evident by the starch test.

At 11 P.M. 12 ounces. Gave no evidence of nitric acid by either test.

In this experiment, previous to any food being taken, nitric acid was found in the urine after a dose of carbonate of ammonia; although before the carbonate of ammonia was taken no nitric acid could be detected in four times the quantity of urine.

For eight hours the nitric acid was detectable by the starch test.

(6.) The same experiment was again repeated, but instead of active exercise there was perfect rest, after taking the carbonate of ammonia.

At $6^h\ 45^m$ A.M. 15 ounces, in which no trace of nitric acid could be detected by the indigo or starch test. At this hour 40 grs. of carbonate of ammonia were taken in distilled water.

At $8^h\ 15$ A.M. 5 ounces passed. The indigo test gave no proof of nitric acid; the starch test showed the presence of a small quantity.

At $11^h\ 45^m$ A.M. $5\frac{1}{2}$ ounces. Both the indigo and starch test gave proof of nitric acid.

At $2^h\ 45^m$ P.M. 4 ounces, in which nitric acid was proved to be present by both tests.

At $6^h\ 10^m$ P.M. $6\frac{1}{2}$ ounces. The indigo test gave no proof. The starch test gave it readily.

At $12^h\ 25^m$ P.M. 10 ounces. Still the starch test showed a trace of nitric acid.

At $7^h\ 40^m$ A.M. 14 ounces. Still the slightest trace by starch test.

Comparing this with the previous experiment, it appears that exercise after the carbonate of ammonia causes the nitric acid to appear in the urine more quickly and to pass out more rapidly. With perfect rest, after twenty-four hours a trace of nitric acid was perceptible. With active exercise, after eight hours it ceased to be detected.

Further experiments were then made to determine what was the smallest quantity of carbonate of ammonia that could cause nitric acid to appear in the urine.

(7.) At 1 P.M. 20 grs. of carbonate of ammonia were taken in 6 ounces of distilled water. Moderate exercise was taken until 6 P.M., when 8 ounces of urine were passed. In this nitric acid was detected by the indigo and starch tests.

At 11 P.M. 7 ounces of urine gave nitric acid by both tests. Urine secreted from $10^h\ 30^m$ P.M. the following night to $7^h\ 30^m$ A.M. the next morning, about 24 ounces, gave no proof of nitric acid by the indigo test, but gave a trace with the starch test.

Still smaller quantities of carbonate of ammonia were taken.

(8.) At $12^h\ 30^m$ A.M. about 7 ounces gave no evidence of nitric acid by the indigo or starch test. At this time 5 grs. of carbonate of ammonia were taken in an ounce and a half of water.

At $5^h\ 55^m$ P.M. $7\frac{1}{2}$ ounces gave no proof of nitric acid by the indigo test; slight evidence by starch.

At $12^h\ 10^m$ P.M. 15 ounces; slightest evidence by starch.

At $7^h\ 40^m$ A.M. 15 ounces; the same.

(9.) At $12^h\ 20^m$ A.M. 12 ounces; doubtful evidence of nitric acid. At this hour 10 grs. of carbonate of ammonia were taken in $2\frac{1}{2}$ ounces of distilled water.

At $6^h\ 50^m$ P.M. 9 ounces; gave proof of nitric acid by the indigo and starch tests.

At $12^h\ 20^m$ P.M. 15 ounces; indigo gave no proof; starch decided proof.

At $7^h\ 30^m$ A.M. 17 ounces; no decided evidence.

Hence it appears that 10 grs. of carbonate of ammonia was the smallest quantity that gave decided evidence of nitric acid by both tests. In the course of ten days, in all, 155 grs. of carbonate of ammonia were taken.

(10.) After this quantity of carbonate of ammonia, the water passed at $7^h\ 30^m$ A.M., as I have said, gave no decided evidence.

At $12^h\ 25^m$ A.M. 12 ounces of urine gave decided evidence with starch; none with indigo.

At $11^h\ 50^m$ P.M. 19 ounces; still evidence of nitric acid with the starch test.

(11.) At $12^h\ 20^m$ A.M. 17 ounces. No evidence of nitric acid; and for the five next days the total quantity of urine passed was collected and examined, and each day the slightest evidence of nitric acid was obtained by the starch test. The examination was continued for the four next days; each day the whole quantity passed was evaporated and distilled, but not a trace of nitric acid could be detected.

Thus seven days after the carbonate of ammonia was omitted still traces of nitric acid could be detected in the urine, if large quantities were evaporated and examined.

In order to be more certain regarding the effect of single doses of carbonate of ammonia, the urine of two children, the one aged seven, the other six, was examined. The total quantity passed by both in the day was 40 ounces. It was evaporated and examined, but no nitric acid could be detected by the indigo or starch tests.

(12.) The child aged seven took 5 grs. of carbonate of ammonia at 11 A.M. The urine passed during the evening and the following morning was in quantity 13 ounces. It was acid, and gave no evidence of nitric acid.

The same child took rather less than 10 grs. of carbonate of ammonia.

(13.) At 8 A.M. the urine made during the day up to the following morning, in quantity 16 ounces, contained a trace only of nitric acid by the starch test.

(14.) The other child, aged six, took rather less than 10 grs. of carbonate of ammonia.

At 8 A.M. the urine first passed after this dose was lost by an accident. The water passed from 5 P.M. to 7 A.M., in quantity 10 ounces, gave no trace of nitric acid.

(15.) The experiment was repeated, 10 grs. of carbonate of ammonia were taken at 8 A.M.

At 6 P.M. about 10 ounces of urine gave nitric acid with the indigo test and with the starch test.

The water from 6 P.M. to the next day at 1 P.M. was lost, but in the water passed during the afternoon and night of the next day no nitric acid could be detected.

(16.) A patient in St. George's Hospital was given 7 grs. of carbonate of ammonia every four hours for rheumatism, after he had taken smaller quantities for three days previously. Twenty-four ounces of urine evaporated gave distinct evidence of nitric acid by the indigo and starch tests.

Experiments with Liquor Ammoniæ.

(17.) A patient was given for ten days small quantities of Liquor Ammoniæ, in all about half a drachm of the Pharmacopœia liquid; twelve ounces of urine evaporated gave evidence of nitric acid with the starch test, but none with the indigo.

Having thus satisfied myself that when carbonate of ammonia was taken small quantities of nitric acid passed off in the urine, I tried whether tartrate of ammonia would give the same result.

Experiments with Tartrate of Ammonia.

(18.) Breakfast and dinner were at the same hours as before.

Water passed from $7\frac{1}{2}$ A.M. to $11\frac{1}{2}$, in quantity 8 ounces, gave slight evidence of nitric acid by the starch test, none by the indigo.

At $11\frac{1}{2}$ A.M. tartrate of ammonia, 60 grs., were taken in 4 ounces of distilled water.

At 3 P.M. 7 ounces of urine gave evidence of nitric acid by the indigo, iron, and starch tests.

At 6 P.M. 7 ounces gave nitric acid with the starch test, but not with the indigo.

At $12^h\ 30^m$ A.M. 10 ounces. Starch test gave evidence of nitric acid.

At $8^h\ 15^m$ A.M. 18 ounces. No evidence of nitric acid by either test.

(19.) Another day. Water at $6^h\ 45^m$ A.M. thrown away.

At $11^h\ 45^m$ A.M. about 8 ounces. Still gave a trace of nitric acid by the starch test. At this hour 40 grs. of tartrate of ammonia were taken in distilled water.

At $6^h\ 20^m$ P.M. 11 ounces of urine gave evidence of nitric acid with the starch test.

At $12^h\ 15^m$ P.M. 7 ounces. Nitric acid much more evidently.

At 7 A.M. 14 ounces. Still distinctly evident.

Up to $7^h\ 30^m$ A.M. the following morning, 54 ounces of water passed contained no trace of nitric acid.

(20.) A child, seven years old, took 20 grs. of tartrate of ammonia in some tea at 8 A.M. Urine secreted from this time to 6 A.M. the following day, in quantity 18 ounces, gave no trace of nitric acid.

As small quantities of nitric acid were detected in two of these experiments previous to the time when the tartrate of ammonia was taken, though the quantity of nitric acid was much increased afterwards, yet further experiments were made. Another healthy person took the same amount of tartrate of ammonia.

(21.) The urine made before the ammonia was taken contained no nitric acid.

At 12 A.M. 40 grs. of tartrate of ammonia were taken dissolved in 6 ounces of distilled water.

At 3 P.M. the urine was acid and contained a trace of nitric acid, by the starch test.

Up to 9 A.M., the following morning, the urine was collected, concentrated and distilled, but not the slightest trace of nitric acid was detected.

(22.) The experiment was repeated at 1 P.M.: 60 grs. of tartrate of ammonia were taken dissolved in 9 ounces of water. In three quarters of an hour it acted on the bowels. The water passed prior to the dose, in quantity $8\frac{1}{2}$ ounces, was examined for nitric acid, but not a trace could be detected.

At $4^h\ 15^m$ urine highly acid, $6\frac{1}{2}$ ounces. It gave a large quantity of nitric acid.

At 11 P.M. 6 ounces. Nitric acid found most readily.

At 8 A.M. nitric acid was not detected.

At $2^h\ 45^m$ P.M. 7 ounces. A considerable quantity of nitric acid was detected.

At 12 P.M. gave a trace of nitric acid.

Experiments with Muriate of Ammonia.

As in the first experiments on the same person, the dinner and breakfast were the same as before.

(23.) Water passed from 7^h 30^m A.M. to 11^h 20 A.M. 7 ounces. When examined for nitric acid no trace was found.

At 11^h 20^m A.M. 120 grs. of muriate of ammonia were taken in 10 ounces of distilled water.

At 2^h 40^m P.M. $7\frac{1}{2}$ ounces of water passed contained so much nitric acid that the distillate required no condensation to give immediate evidence by all the tests.

At 5^h 50^m P.M. 8 ounces. No trace of nitric acid was found.

At 11^h 45^m P.M. 8 ounces. No nitric acid was detected.

At 7^h 35^m A.M. 19 ounces. In this larger quantity a trace of nitric acid was found.

At 7^h 35^m A.M. the day following, 42 ounces. Contained no trace of nitric acid; to 7^h 35^m A.M. the day following, 38 ounces. The slightest trace of nitric acid was detected.

(24.) The same person took 10 grs. of muriate of ammonia.

The water passed from 7^h 30^m A.M. to 11^h 10^m A.M., in quantity 4 ounces, previous to the muriate of ammonia, contained scarcely a trace of nitric acid.

At 11^h 10^m A.M. 10 grs. of muriate of ammonia were taken in distilled water.

At 2^h 30^m P.M. 5 ounces of water contained so much nitric acid that it was detectable without evaporating the distillate.

At 6^h 50^m P.M. 5 ounces. The evaporated distillate gave nitric acid most readily.

In this experiment a trace of nitric acid was found in the urine passed previous to the taking of the muriate of ammonia. The occurrence of minute traces of nitric acid after breakfast was also observed in (9.), (18.), (19.) and (25.); from these observations it is not improbable that the nitric acid came from minute quantities of the salts of ammonia occasionally present in the food.

(25.) By another person, 25 grs. of muriate of ammonia were taken.

The urine made just previous to the medicine, was examined at midday; it contained a small quantity of nitric acid by the starch test, perhaps resulting from the tartrate of ammonia previously taken.

At 12 o'clock 25 grs. of muriate of ammonia were taken in water.

At 1^h 30^m P.M. a very considerable quantity of nitric acid was detected by all the tests.

At 4 P.M. nitric acid was detected without concentrating the distillate.

At 12 P.M. no nitric acid could be detected.

At 8 A.M. no nitric acid was found.

(26.) A child, six years old, was given 10 grs. of muriate of ammonia in tea, at breakfast. The urine made during the day, up to 6 o'clock the following morning, in quantity 20 ounces, contained only a small quantity of nitric acid by the starch test.

(27.) A child, seven years old, was given 5 grs. of muriate of ammonia in tea, at breakfast. The urine made during the day, and up to 8 o'clock the following morning, in quantity 16 ounces, contained a considerable quantity of nitric acid, by indigo, starch and protosulphate of iron tests.

Finding that salts of ammonia *in transitu* through the body gave rise to nitric acid, I made the following experiment to see whether out of the body nitric acid could be produced by the direct combustion of ammonia.

Ammoniacal gas was passed into alcohol. This ammoniacal alcohol, specific gravity about ·861, was burnt in a spirit-lamp: the products of combustion were passed through a dilute solution of carbonate of potash by means of an aspirator. In all about 3 ounces of alcohol were burnt, the combustion lasting one hour. The solution of carbonate of potash was tested for nitric acid, without being evaporated to a smaller bulk; and the presence of nitric acid was most distinctly proved by the starch test, by the indigo test, and by the protosulphate of iron test. Thus by simple combustion out of the body, as well as in the body, nitric acid was produced.

The close relation of urea to carbonate of ammonia immediately gave rise to the idea that possibly it also would be changed *in transitu*.

Experiments with Urea.

(28.) At $11^h\ 30^m$ A.M. 20 grs. of urea were taken in 3 ounces of distilled water.

At 6 P.M. the slightest trace of nitric acid was found by the starch test in 9 ounces of urine.

At $12^h\ 30^m$ P.M. about 9 ounces of urine gave no nitric acid.

At $7^h\ 30^m$ A.M. 11 ounces gave no trace of nitric acid.

(29.) The experiment was repeated with 40 grs. of urea.

The urine passed from $7^h\ 30^m$ to $11^h\ 45^m$ A.M. was about 5 ounces; it contained no trace of nitric acid.

At $11^h\ 45^m$ A.M. 40 grs. of urea were taken in 4 ounces of distilled water.

At 6 P.M. about 12 ounces of urine gave evidence of plenty of nitric acid by the indigo test and the starch test.

At 12 P.M. about 7 ounces. No proof of nitric acid.

At $7^h\ 30^m$ A.M. about 12 ounces. Gave no proof.

To $7^h\ 30^m$ A.M., the following morning, the urine in quantity 48 ounces, gave no trace of nitric acid.

(30.) These experiments were also made on another person.

At 12 A.M. 20 grs. of urea were taken dissolved in 5 ounces of water.

At $1^h\ 30^m$ P.M. 6 ounces of urine passed, acid to test-paper. Gave with the starch decided proof of nitric acid.

At 4 P.M. 3 ounces gave slighter proof of nitric acid.

To 9 A.M. the water when evaporated and distilled gave no evidence of nitric acid.

(31.) On another day 40 grs. of urea were taken.

At $11^h\ 30^m$ A.M. 40 grs. of urea in 5 ounces of distilled water.

At $1^h\ 30^m$ P.M. 7 ounces of acid urine gave evidence of nitric acid by the starch test.

At $5^h\ 30^m$ P.M. nitric acid was present.

Up to $9^h\ 30^m$ A.M. In the total quantity passed nitric acid, in small quantity, was found by the starch test.

In order to determine whether the same effect would be produced out of the body by combustion of the urea, some urea was dissolved in alcohol, the specific gravity of the solution =·851; it was burnt in a spirit-lamp; the products of combustion were collected for one hour. The carbonate of potash solution was examined for nitric acid, and without any concentration it was found by all the tests.

Thus, then, whether in the body or out of the body, urea, by oxidation, gives rise to nitric acid.

In St. George's Hospital the urine of two patients with dropsy and albuminous urine, in whose blood urea might be considered to be probably present, was examined for nitric acid. In each case a pint of the urine was boiled, filtered and distilled, but no trace of nitric acid was found. In one case the experiment was repeated with two pints of urine, but still only a negative result was obtained.

These experiments with urea showed that when small quantities were taken no nitric acid could be detected; this led me to suppose that a large dose of the alkaloids would be necessary to produce any decided effect on the urine, and on this account no alkaloid was taken.

Caffein, however, was dissolved in alcohol, and when burnt for one hour in a spirit-lamp, it gave rise to nitric acid.

As it appeared from these experiments that nitric acid was produced more readily and frequently than has been supposed to be the case, I was led to try whether combustions in the atmosphere, without ammonia, could not give nitric acid.

I first tried the products of the combustion of alcohol. The spirit-lamp was used as before, and the products of combustion were passed through a solution of pure carbonate of potash. The alcohol had not the slightest alkaline reaction, but after an hour's combustion nitric acid was proved to exist in the carbonate of potash, by the starch test, and by the indigo test also.

As it was possible that a small quantity of ammonia might have been present in the alcohol, I determined to collect the product of hydrogen burnt in the air. The gas was generated by pure sulphuric acid and distilled water, and it was burnt for one hour; nitric acid was found to be present in the carbonate of potash in small quantity*.

The combustion of coal in a small furnace was then made, so that the products

* After this paper was written, I found that SAUSSURE had described a similar experiment in the Annales de Chemie for 1809, vol. lxxi. p. 285. Nitric acid and ammonia were detected by him after the combustion of hydrogen gas in atmospheric air.

were passed through dilute carbonate of potash; after an hour no trace of nitric acid could be detected.

The experiment was repeated with a brisker fire, and a trace of nitric acid was found.

By the combustion of a wax candle, a slight trace of nitric acid was detected after it had burnt one hour.

The product of the combustion of ordinary coal-gas gave plenty of nitric acid. To purify it from ammonia, it was passed through dilute sulphuric acid; nitric acid in much smaller quantity than before was then detected.

This experiment was repeated, passing the coal-gas through a tube 3 feet long, full of asbestos and pumice-stone moistened with strong sulphuric acid, and then through a thin layer of strong sulphuric acid. After combustion for an hour, nitric acid was detected by all the tests. When the laboratory air was passed for an hour through the same solution of carbonate of potash, no trace of nitric acid could be detected. When the atmospheric air, as well as the coal-gas, were first passed through tubes containing sulphuric acid, and afterwards burnt for one hour, nitric acid was detected among the products of combustion, by the starch and by the indigo test.

If instead of depriving the gas of ammonia it was made to pass over the vapour of ammonia and then burnt, nitric acid could be detected by the starch test with the greatest certainty after two minutes' combustion; but with the same flame, after six hours' combustion, I was unable to obtain any very considerable quantity of nitrate of potash.

These experiments on the production of nitric acid in all cases of combustion in the air, render it very probable that small quantities of nitric acid exist always in the atmosphere, and that nitric acid will be constantly detected in rain and snow, not only after a thunder-storm, but at all other times also. At least, by adding pure carbonate of potash to rain-water, and evaporating it to a very small bulk, I have succeeded in detecting nitric acid in the water which fell in London, on a continuously rainy day in December. Fourteen pints, when evaporated to two ounces, furnished positive proof of the presence of nitric acid by the indigo, starch and iron tests.

On another day ten pints, evaporated to a very small bulk, gave evidence of nitric acid.

Should nitric acid be found to be present in the air at all times and in all places, its importance to the growth of plants will not be less than that of the ammonia which has been detected there.

Thus, whether in the body or out of the body, the oxidation of ammonia gives rise to a combination of oxygen with nitrogen. Nitrous and nitric acids are produced. It is very difficult to determine the quantity of these acids formed in the body, but the experiments mentioned above prove that some portion of the nitrogen is oxidized in the passage of ammonia through the system.

The importance of this oxidizing action in effecting a change in the injurious substances which happen to be present in the blood, cannot be overlooked, when experiment proves that urea *in transitu* is partly converted into nitric acid. Whether nitric acid is thus made to appear in the urine in any diseases, is a question of great interest.

The conclusions I come to from my experiments are,—

1st. That the action of oxygen takes place in the body, not only on hydrogen, carbon, sulphur and phosphorus, but also on nitrogen.

2ndly. That in all cases of combustion, out of the body and in the body, if ammonia is present, it is converted partly into nitric acid.

3rdly. That the nitrogen of the air is not indifferent in ordinary cases of combustion, but that it gives rise to minute quantities of nitric acid.

The general result is, that the production of nitric acid from ammonia in the body adds another to the many instances of the action of oxygen in Man.

In the formation of water and carbonic acid, oxygenation has long been recognized as the great cause of the animal heat.

In the Philosophical Transactions for 1846 and 1850, I have endeavoured to show that the excretion of phosphoric and sulphuric acids in excess may be the means of ascertaining in what tissue the most energetic action of oxygen is taking place.

In the present paper, it appears that the detection of nitric acid in the urine may lead to the conclusion, that the blood is being freed from ammonia, or from substances closely related to it, as urea, or possibly caffein and other alkaloids.

The same action then takes place in the fluids of the body as occurs in wells and streams when tainted with sulphuretted hydrogen and ammoniacal animal matter. In the body, as well as out of it, from these substances, sulphuric and nitric acids are produced by the purifying action of the oxygen of the atmosphere.

APPENDIX.

On Nitric Acid in Rain-water.

During January, on different wet days, rain-water was collected in London and decreasing quantities were evaporated with perfectly pure carbonate of potash; and I found that nitric acid was always present and could be detected even in a pint of rain-water by the starch test.

Moreover, in rain-water collected about the same time at Kingston in Surrey; at Melbury in Dorsetshire, many miles from any town; and near Clonakilty in the county of Cork, when a south-west wind was blowing, I found distinct evidence of nitric acid.